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Comparison of
BAG AND BULK SHIPMENTS
OF DRY EDIBLE BEANS



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PREFACE

The Market Quality Research Division was asked to cooperate with the dry bean industry in studying bulk shipment of dry edible pea beans. The Division was requested to study and develop the best method for loading and unloading that would assure delivery with a minimum of cracked seedcoats and broken beans.

Dry edible pea beans were shipped from Michigan, Indiana, Nebraska, and New York to canners. This study compares bagged shipments in regular noninsulated cars with bulk shipments in insulated dual-hopper steel cars and in insulated remodeled RBNX Fruit Growers Express cars. Some truck shipments were also made using bulk boxes (tote boxes).

Use of brand or trade names in this report is for identification of the equipment used in the tests, and this use does not constitute endorsement of the materials or equipment named or imply discrimination against other products.

The authors wish to acknowledge the cooperation of the following commercial firms: H. J. Heinz Co., Pittsburgh, Pa., and Campbell Soup Co., Camden, N. J., for making available bulk shipments of beans; the Michigan Bean Co. (Division of the Wickes Corporation, Saginaw, Mich.), for installing special handling equipment; Chester B. Brown Co., Morrill, Nebr., and N. K. Hurst Co., Indianapolis, Ind., for cooperative shipments of Great Northern Beans; and Cooperative Grange League Federation, Canandaigua, N. Y., and Brown Canning Co., Mexico, N. Y., for making available 1-ton bulk boxes of bulk beans for truck movement.

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COMPARISON OF BAG AND BULK SHIPMENTS OF DRY EDIBLE BEANS

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SUMMARY

Because canners and other processors objected to the condition in which pea beans arrived at their plants, studies were made to determine whether more efficient modes of transportation are available or could be developed.

Ten tests were made over a 2-year period with bagged beans shipped by rail and shipped by truck and rail in bulk and in bulk boxes. Under the various combinations of stacking containers, type of transport, and methods of loading and unloading used in this study, bean quality was maintained.

Special insulated (RBNX) Fruit Growers Express cars were modified with sloping floors to the center door and lined with marine plywood so that bulk beans could be unloaded by gravity flow. This modified insulated car reduces temperature and moisture fluctuations during transit and so helps maintain the quality of the beans at destination. Because of ease of loading and unloading, this modified insulated car is also preferred to the standard noninsulated boxcar. Recently there have been improvements of insulated dual-hopper cars in providing unloading from the bottom and this feature may provide even greater ease of unloading than the modified insulated car. Such a car was not available when these tests were made.

Each bag was probed at a designated spot marked before shipment to correspond to the position at which the original probing was made. In addition, the bag was probed at random at different points. Sampling at the marked spots gave more accurate analyses than did random sampling. A pneumatic probe was used successfully at destination to sample bulk beans; it was almost impossible to reach the bottom of the car with a standard grain probe because of settling of the beans.

Advantages of bulk shipping include elimination of the long and costly process of bagging and sewing, the need for bag conveyors and handtrucks, the tedious hand-stacking operations, cost of bulky pallets, and the expense of dumping, cleaning, and marketing second-hand burlap bags. Loading time is reduced nearly 75 percent. Using the same crew (five men) it takes about 50 minutes with a flexible tube or conveyor belt to fill a hopper car with bulk beans, compared to $3\frac{1}{2}$ hours for the bagged product.

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As a final advantage, bulk shipping makes sampling much easier and more representative. The inspector gets a more representative sample from a pneumatic bulk probe or from the continuous flow of beans than he does by probing 10 percent of the bags.

INTRODUCTION

Bag Shipments

The loading pattern (interlock) designed to minimize shifting of the bags during switching and rough cross-country rail trips has been used by some shippers (fig. 1). Figure 2 shows the result of shifting from one end to center, when bags are not interlocked, causing broken bags when the doorway is forced open.

Canners have complained to the dry bean shippers that they occasionally receive shipments of bagged beans that contain excessive amounts of broken beans and cracked seedcoats. These damaged beans, which were found more often in the bagged noninsulated car or truck shipments, must be screened out or an inferior canned product will result.

For several years canners have observed that in bagged beans moisture content is inversely related to the percentage of split beans and cracked seedcoats. Sound beans shipped at 18-percent moisture content showed less than 0.2 percent splits on arrival. However, at lower moisture levels (14 and 15 percent), 0.4 to 0.5 percent splits could be expected. At 12 to 13 percent moisture, splits averaged between 0.8 and 0.9 percent. When beans contain low moisture, the incidence of cracked beans is higher during processing. If the cotyledons have not separated, the cracked seedcoats may show up in the processed product as loose hulls.^{2/}

Bulk Shipments

Standard noninsulated boxcars and covered hopper cars used for hauling bulk grain are considered unsatisfactory for shipping graded bulk pea beans because of contamination with other grains and foreign material (nails, splinters, dirt, and the like).

Bulk shipments of dry edible beans have been unpopular because the country shipper is not equipped to load bulk beans and only a few of the terminal elevators and canners have facilities to unload them. However, Thompson^{3/} has shown that bulk handling of beans could be economical.

The initial bulk shipment was made in 1956 from Saginaw, Mich., in a noninsulated covered hopper car to Camden, N. J. The beans were moldy on arrival and were considered unsatisfactory.

^{2/} Sidwell, A. P., Sefcovic, M., and Thompson, J. A. Sorting Beans by Electronics. Agr. Mktg. 2(4): 4-5, illus. April 1957.

^{3/} Thompson, Judson A. Bulk Shipping of Navy Beans. Agr. Mktg. 3(8): 5, illus. August 1958. (Out of print; may be consulted in major libraries.)



BN 22876

Figure 1.--Standard boxcar at origin loaded with 800 interlocked 100-pound bags.



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Figure 2.--Bagged car at destination showing shifting of bags (not interlocked).

Prior to the introduction of specially designed unloading equipment, bulk beans were unloaded into fiber drums from railroad cars (fig. 3). These drums held between 200 and 300 pounds of beans, and lift trucks with a pallet carried 4 drums at a time.

The first tote boxes used for shipping bulk beans were built of wood and were low and wide so that they could be easily stacked. These 1-ton bulk boxes were so easily damaged in moving that they were not accepted by the canners. The recommended tall and narrow box can be filled quickly from a spout directly from the weighing hopper (fig. 4). These steel tote boxes are about 6 feet high and 3 feet square with a bottom tapering to one side with a sliding door.



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Figure 3.--Bulk beans being unloaded into fiber drums.



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Figure 4.--Filling 1-ton steel tote boxes, before cleaning.

QUALITY STUDIES OF BAG TRUCK AND RAIL SHIPMENTS

Handling Methods

The study of more efficient handling methods for bagged beans has been accelerated by increased labor costs. Formerly, the beans were cleaned and bagged for storage immediately after harvest. To fill orders they had to be hand-trucked again for loading. In recent years, the handtrucking method of hauling five 100-pound bags at a time has largely been replaced by a belt conveyor from the bagging equipment or storage pile to the door of the boxcar or truck. The bags are taken off the belt at shoulder height (so that loaders do not have to lift from floor level) and placed in the car or truck. The belt method is less time-consuming than the handtrucking method; however, inexperienced loaders often drop the bags from shoulder height to the floor of the car or truck. This practice of dropping the bags in place is largely responsible for an increase in cracked seedcoats in the bottom tier of bags at destination. For example, a truck shipment of Great Northern beans was sampled at a loading point in Morrill, Nebr. and again at a packaging plant in Indianapolis, Ind., in the fall of 1956, to determine quality changes. In this lot, samples were taken from eight bags on the top tier, from eight on the bottom tier, and from four in the center of the pile. The samples were analyzed in our Beltsville, Md., laboratory for splits, cracked seedcoats, and other defects. At origin, the samples from the bottom tier of bags averaged 1.2 percent splits and 13.5 percent cracked seedcoats. At destination, the averages were 1.1 and 14.3 percent, respectively, indicating little difference in splits, but an increase of 0.8 percent in cracked seedcoats. No significant difference was detected between the center and top of the load, but the bottom tier was damaged because of impact in loading and additional weight on each bag.

Sampling Methods

Special sampling studies were made of spot-marked bags at designated locations within the test cars. Each bag was probed at a designated spot marked prior to shipment, which corresponded to the position at which the original probing was made. In addition, the bag was probed at random at different points. A standard bag probe was used.

Temperature Changes in Bag Shipments

Ryan recording thermometers were placed in the bottom, 4th, 6th, and 8th (top) tier of bags, and another Ryan thermometer was attached under the car to measure outside temperatures. Thermocouples were used in some bags, selected at random (top, center, and bottom) to obtain more temperature data (fig. 5).



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Figure 5.--Thermocouples installed in bags.

Ten-inch dial thermometers were used to obtain additional readings on selected bags in designated locations during the trip.

In a standard noninsulated boxcar during the day (12-hour period), the maximum outside reading was 84° F., while the overhead air temperature in the car was 87°. The average temperature of the bottom tier of beans was about 5° lower than the temperature of beans in the fourth, sixth, and top tiers. Temperatures within the bags touching the walls were essentially the same as those on the bottom tier. Immediately after loading, the temperatures at the bottom tier dropped to about 65° and then rose slowly to 68° and cooled rapidly to 61°, reflecting the changing outside temperatures. In the center of the car (fourth tier), while in transit, the temperature of the beans slowly increased from 65° to 67°. In the sixth tier, temperatures increased from 65° to 70°, then cooled to 67°. The temperature of the bottom tier approximated the outside temperatures.

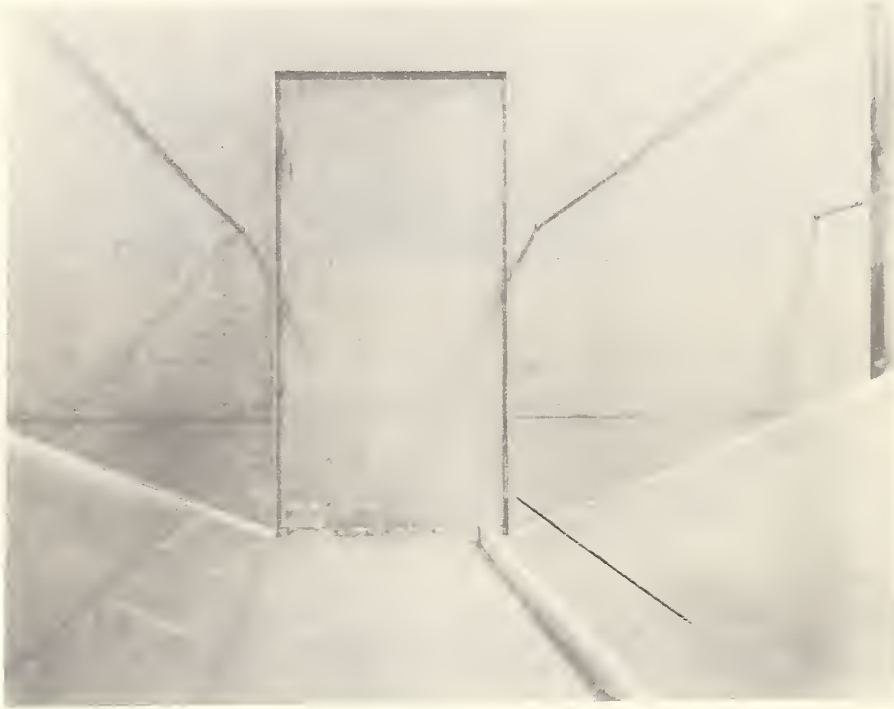
QUALITY STUDIES OF BULK TRUCK AND RAIL SHIPMENTS

Sampling Methods

Beans in bulk settle in transit, and probing to the bottom of the car at destination with a standard grain probe was extremely difficult and in some cases impossible. Therefore, a pneumatic probe, which pulls the desired sample by vacuum through extension pipes, was used to permit adequate sampling.

Shipping Units

The Fruit Growers Express Co., Alexandria, Va., cooperated with the bean industry by rebuilding RBNX-type insulated refrigerator cars for rental to bean processors. These rebuilt cars were used for shipping bulk beans from Michigan shipping points to canning plants. The empty cars were returned to the shipper for reloading after each use. These cars were lined with marine plywood and equipped with reinforced floors sloping at an angle of 22° from the sides to the center of the car to facilitate unloading (fig. 6).



BN 22881

Figure 6.--Rebuilt insulated refrigerator car used for bulk bean shipment.

The first rebuilt RBNX car was equipped for loading with four staggered hatches in the roof along both sides of the catwalk near the center of the car. In order to load 80,000 pounds of beans evenly throughout the car through the hatches at the center of the car, the beans had to be shoveled by hand from the center hatches to both ends. When the car was loaded without shoveling, the beans did not level off in transit as was expected. For instance, the hatches were filled to the top opening at Saginaw, Mich., and at destination the beans had only settled 18 inches.

Ten loading hatches were placed in the roof of the second rebuilt RBNX car, located on either side of the catwalk. Figure 7 depicts the flexible tube method of loading from an overhead bin. However, if an endless adjustable belt conveyor were used (fig. 8), the number of loading hatches could possibly be



BN 22882

Figure 7.--Flexible tube method of loading from an overhead bin.



BN 22883

Figure 8.--Adjustable belt conveyor used for loading beans.

reduced to four. By the use of a divided hopper at the end of the conveyor belt, the beans could be directed to two hatches at one spotting and the car would have to be moved only once during loading. If the hopper at the end of the belt is large enough to store three or four dumps from the scale while the car is being respotted, and if the cleaning and weighing equipment could continue operation, an 80,000-pound-capacity car could be loaded in approximately 1 hour.

The shipment of bulk beans in approximately 1-ton bulk units was studied in cooperation with the Cooperative Grange League Federation Exchange, Inc., at its Caledonia, N. Y., plant. This shipment of pea beans was hauled in specially constructed, self-cleaning, tote boxes with forklift slots near the bottom so that the unit could be loaded on motor trucks by lift trucks.

Temperature Changes in Bulk Shipments

In the first bulk lot shipped in an insulated remodeled car, bean temperatures fluctuated widely during transit. Thermocouples and recording thermometers were placed at various depths and locations throughout the cars and readings were taken before and during loading. Temperatures at both ends of the car fluctuated more than at the center area because the depth of beans was less in the center due to the insulating effect of the beans. No significant temperature change was recorded in the center of the car while in transit.

Temperature changes and moisture migration in a second bulk shipment were studied carefully. Thermocouples were located along the wall of the insulated remodeled car at 0, 3, 6, 9, 12, 18, and 24 inches from the side wall.

Readings were recorded before unloading (table 1). Temperature differences were not significant.

Table 1.--Temperature variations in bulk beans at destination before unloading in an insulated car during October

Location of thermocouple from side wall in inches	Temperature (°F.)			
	Original	Top	Side	Bottom
0	59	53.3 ^{1/}	54.5	54.5
3	59	55.0	54.5	56.0
6	59	56.0	57.5	56.5
9	59	57.0	57.5	--
11-18	59	58.0	58.0	57.0
16-18	59	58.0	58.5	57.5
24	59	58.5	58.2	57.5

^{1/} Air temperature.

A third shipment was made in midwinter (January). The temperature of the beans at loading was 39° F. At destination, some of the beans near the ends of the insulated car had reached the freezing point or below (table 2). Temperatures were recorded in a noninsulated steel dual-hopper car for shipping bulk beans from Saginaw, Mich., to Camden, N. J. In one end of the car, steel cup brackets were welded to the center slope in the car so that one recording thermometer would be near the surface of beans, a second near the center, and a third near the bottom. Temperatures at the center of the load increased less than at the other two locations (table 3).

Table 2.--Transit temperature variations in bulk beans (January) in an insulated car

Location of thermocouple: from side wall in inches	Temperature when location of thermometer was at-								
	Top		Side		Bottom				
	Origin:Destin.		Origin:Destin.		Origin:Destin.				
	°F.	°F.	°F.	°F.	°F.	°F.			
0	28.5	30.0	34.5	29.5	33.0	31.0			
3	37.5	31.5	39.0	29.5	39.0	31.0			
6	38.5	31.0	40.0	29.5	38.5	31.5			
9	38.5	31.5	39.0	-	38.5	33.5			
12	38.5	32.5	39.0	31.5	39.0	35.5			
18	38.5	32.5	39.5	30.0	39.0	36.5			
24	37.5	33.5	39.0	31.5	39.0	36.5			

Table 3.--Average daily temperatures of bulk beans at different depths in a covered-hopper steel noninsulated freight car (April)

Time (days)	Temperature when location of thermometer was at-		
	Top	About 2 ft. from top	Bottom
	°F.	°F.	°F.
0	46	37	47
1	46	38	48
2	48	39	49
3	51	40	56
4	53	42	57
5	56	43	60
6	59	44	58
7	60	46	60
8	65	48	65
9	67	50	65
10	67	52	68
11	*	54	68

*Thermometer removed.

In a truck shipment, thermocouples were placed at 0, 3, 6, 12, 15, 18, 24, and 36 inches from the bottom. In addition, one thermocouple was located on the surface layer, one thermocouple 2 inches deep, and one under the truck. All thermocouple readings read about 76.5° F. after loading except at the surface (80°) and 2 inches under the surface (79.2°). The temperature recorded under the truck was 87° F. In 7 hours of travel the average temperature of the beans increased from 76.5° to 79°, or an increase of 2.5°. The surface temperature of the beans at destination was 84.5° and at 2 inches depth was 85°.

Moisture Migration Study

Thompson and Perry^{4/} found that in steel noninsulated cars, moisture migration in beans is a serious problem, particularly when bean moisture contents are high (18 percent) and when temperature changes are great.

However, in the insulated Fruit Growers Express cars, it was found that the insulation effectively reduced temperature changes in the bulk beans so that little migration of moisture took place. Small 2-pound nylon screen bags were filled with beans and placed on the center upright post and on one side wall. When the car was unloaded and each nylon bag uncovered, it was quickly placed in a moistureproof bag to be held for moisture analysis.

^{4/} Thompson, J. A., and Perry, J. S. Storage of Pea Beans in Michigan and Indiana. U. S. Agr. Mktg. Serv. AMS-123, 78 pp., illus., May 1956.

Differences in moisture content at varying depths in the car, either at the wall or in the center of the load, were not significant. The moisture content of the air and of the beans at different positions in the load was about the same.

In a test shipment, steel tote boxes were filled with pea beans loaded at Caledonia, N. Y., and shipped by truck to Mexico, N. Y., with very little change in moisture. The average moisture content of the samples at origin and at destination was about 15.5 percent.

COMPARISON OF BAG AND BULK SHIPMENTS

An experiment was conducted to determine whether beans containing less than 15-percent moisture, or beans below freezing temperatures, are more susceptible to physical damage in handling than beans containing 18 percent or more of moisture and with temperatures above freezing. Data from the remodeled RBNX Fruit Growers Express bulk car were compared with the data from the standard bag boxcar in this experiment.

A 2-by-4-inch post was braced from the top of the RBNX car to the floor and nailed to a crosspiece attached to the top of three crossbrace rods. Ryan recording thermometers were installed near the bottom, center, and top of the post. One thermometer was mounted midway up the wall and another midway up the sloping floor (see extreme top left and top center, respectively, fig. 9). To record outside temperatures, one Ryan thermometer was placed under the car. In addition, thermocouples were installed at locations from 0 to 36 inches up from the bottom of the car and 0 to 36 inches from the side of the car.



BN 22884

Figure 9.--Insulated bulk car (RBNX) showing equipment for obtaining temperature changes.

Temperature Study

The temperatures of beans in the various positions in four bagged and four bulk shipments are tabulated in table 4. Maximum temperature variations were found at the bottom and top of all cars tested. Temperature fluctuations were greater in the bottom tier than in the center tier. Temperatures in the top tier of bags were influenced substantially by the overhead air temperature and fluctuated as much as 20 degrees. In the bulk shipment, the car insulation helped to reduce temperature fluctuations. In the center of the bulk beans, the maximum temperature change was only 3 degrees from loading temperature. While being loaded into an insulated car, bulk beans showed an average temperature of 38° F., in spite of the outside temperature of 10° to 12°. During the first 6 days of this shipment, the outside temperature ranged from 0° to 20°. The beans cooled to freezing to a depth of about 12 inches down from the top and approximately 6 inches up from the bottom. The thermocouples close to the floor read near freezing. Most of the bulk beans in the insulated car, however, were maintained above the freezing point in spite of the extreme cold weather. The insulated car was especially beneficial in maintaining the temperature of most of the beans above the freezing point.

In the bagged beans shipped at the same time in a standard boxcar, temperatures recorded in every bag in the car were below freezing. The average of the six designated bags on the floor was 24° F., with a range of 20° to 26°. The temperature range was almost identical in the center at the fourth tier level, with an average of 22°. In the sixth tier, the beans averaged 25° with a range of 23° to 28°, while, in the eighth (top) tier the temperature averaged 30°.

Loading and unloading temperatures of eight test cars of bagged and bulk bean shipments are compared in table 5. Differences were not significant.

Moisture Study

In the insulated RENX cars, moisture changes between origin and destination were small, indicating the advantage of insulation in reducing temperature changes during shipment. In bagged beans in noninsulated cars, temperature changes were greater. In one car, 20 samples were drawn from test bags representing samples from the first, fourth, sixth, and eighth tiers. Samples were drawn from the bulk car at 5-foot intervals near the surface down each side and middle of the car at a depth of 8 inches. Periodic samples (19 in all) were also taken from the stream of beans in the unloading spout. Average moisture at origin was determined on a composite sample taken at Saginaw. The moisture analysis comparisons are shown in the following tabulation:

<u>Kind of railcar shipment</u>	<u>Original moisture</u>	<u>Moisture at destination</u>	<u>Difference</u>
	(%)	(%)	(%)
Bagged	17.92	19.10	+1.18
Bulk	17.97	18.74	+0.77

Change in the bean moisture content in the bulk shipment was negligible, while moisture content in the bagged shipment fluctuated with the outside weather conditions (table 6).

Table 4.---Temperatures of bagged and bulk beans from a series of four-paired shipments of Michigan pea beans in standard noninsulated and insulated RBNX cars

Shipping month	Standard boxcar (bagged beans)		Insulated RBNX car (bulk beans)	
	Average temp. (°F.) of loading		Average temp. (°F.) of loading	
	Location of Ryan thermometer	Bean temp. (°F.) of bulk beans	Location of Ryan thermometer	Bean temp. (°F.)
	High	Low	High	Low
Sept.	67	69	67	65
	Near floor	61	3 ft. from floor	66
	3 ft. from floor	65	Slope	72
	5 ft. from floor	70	1 ft. from surface	67
	Top of load	82	Wall	73
	Outside temp.	84	Above beans	75
Oct.	61	58		60
		60	Floor	55
		62	Center	54
		62	Slope	55
		62	Wall	54
		63	Above beans	54
Jan.	40	30		
		32	Floor	25
		40	Center	36
		32	Slope	26
		36	Wall	30
			Above beans	34
Sept.	69	63		
		67		
		64	Center	73
		72	Slope	60
		84	Above beans	59

Table 5.--Loading and unloading temperatures of bagged (noninsulated car) and bulk beans (insulated car)

Temperatures when loading at Saginaw				Temperatures when unloading at Pittsburgh			
Outside	Bagged	Bulk		Outside	Bagged	Bulk	
°F.	°F.	°F.		°F.	°F.	°F.	
67	67	67		50	67	66	
74	61	59		47	59	56	
12	39	39		33	33	37	
59	69	72		74	65	73	

Table 6.--Moisture changes in four bulk and four bagged bean shipments

Type of shipment and original moisture	At destination							
	Bottom tier		Center tier		Near top		Top	
	Mois- ture	Change	Mois- ture	Change	Mois- ture	Change	Mois- ture	Change
	%		%		%			
Bagged beans in noninsulated cars:								
18.1 percent	19.1	+1.0	19.0	+0.9	19.4	+1.3	18.5	+0.4
17.9 percent	17.8	-0.1	17.8	-0.1	17.8	-0.1	18.1	+0.2
17.0 percent	16.4	-0.6	16.5	-0.6	16.5	-0.5	16.4	-0.6
14.8 percent	17.8	+3.0	17.8	+3.0	17.9	+3.1	17.8	+3.0
17.0 percent, average	17.8	+0.8	17.8	+0.8	17.9	+1.0	17.7	+0.7
Moisture at destination				Change				
%								
Bulk beans in insulated cars:								
18.1 percent		18.3				+0.2		
18.0 percent		18.1				+0.1		
17.2 percent		17.4				+0.2		
16.0 percent		16.0				0.0		
17.3 percent, average		17.4				+0.1		

RESULTS AND DISCUSSION

Country shippers were reluctant to risk shipping a car of bulk beans to market if there was any possible chance of the lot being rejected on arrival. Rejection would require returning the bulk bean shipment to the country shipping point for bagging or reprocessing, and would cause a substantial financial loss. In order to prevent such loss, very careful and thorough inspection is necessary at country shipping points to assure that the bulk-shipped beans at destination will be the same grade and quality as bag-shipped beans that are purchased by the canner.

There is considerable enthusiasm in the edible dry bean trade regarding the shipment of bulk beans to canners and other destination distributors. The research in this report indicates that the quality of bulk beans can be maintained by reducing temperature and moisture fluctuations when they are shipped in special insulated cars or trucks, and if proper precautions are exercised at time of loading and unloading. Such precautions would include careful handling to avoid excessive losses, as unusually dry beans are apt to split or develop cracked seedcoats.

With an endless conveyor, it takes only about 50 minutes to fill a modified insulated boxcar with bulk beans, compared to $3\frac{1}{2}$ hours for loading bagged beans.

Furthermore, a more representative sample can be obtained from a pneumatic bulk probe than by probing about 10 percent of the bags with a hand probe. The pneumatic bulk probe caused negligible damage to the beans.